Football Participation and Chronic Traumatic Encephalopathy

CASE SCENARIO
A 13-year-old male athlete presents to the clinic with his parents for a preparticipation physical examination. The athlete has participated in soccer, baseball, and track in the past but is very interested in joining the football team this year. His parents are hesitant for him to participate in football because they have heard about a brain injury in football players called chronic traumatic encephalopathy (CTE). They would like your advice regarding whether their child should avoid football due to the risk of developing CTE. The athlete is an above-average student and aspires to go to college and become an engineer. He has no significant medical or surgical history. Specifically, he has never sustained a previous brain injury. He does not take any medications. He does not have a history of psychiatric disorder or learning disability. He denies smoking, drinking alcohol, or taking illicit drugs. His family history is significant for migraine headaches in his mother and maternal grandmother.

Scott R. Laker, MD, Responds

All physiatrists who care for youth athletes should be prepared to have this conversation, and all sports medicine providers should be well versed on the topic of safety in youth tackle football. I would recommend if one is not current on this literature base or uncomfortable with the vagaries of this clinical situation that a referral to a sports medicine specialist be made. This family is seeking advice about chronic traumatic encephalopathy (CTE) as it relates to youth tackle football. It is important to clarify that this family is asking for a preparticipation physical, where the standard for disqualification would be the clear and present danger of injury or death due to participation. I feel that this standard for disqualification goes above and beyond the current understanding of CTE and places the provider who chooses to disqualify an athlete from participation in football due to the risk of CTE in an untenable and unsupported position. In addition, the provider should ask themselves, “Am I willing to de facto disqualify every youth athlete I see from participating in football, even if the family supports participation?”

The preparticipation physical evaluation involves a thorough history and physical examination, recommendations for necessary follow-up testing, and determination of the safety for participation. From an ethical standpoint, the physician performing the preparticipation physical evaluation is duty bound to provide impartial information so that the athlete and their parents can make an informed consent to participate (ie, autonomy) and to support the health of this athlete (ie, beneficence) [1]. The final decision regarding participation on the football team will largely be up to the parents rather than the child. I would clarify that I do not have a personal stance on his participation and would support their decision to participate, not participate, or to defer the decision until the athlete is older and more information is available. Although the American Academy of Pediatrics recommends vigorous discouragement of participation in youth boxing, it has no similar policy statement for football [2]. I would give the family examples of situations in which I would recommend disqualification from participation in football (eg, atlantoaxial instability, multilevel Klippel–Feil anomalies, etc).

The major symptoms associated with CTE include cognitive decline, behavioral abnormalities, and mood changes. These symptoms cover a wide spectrum of
severity, are nonspecific, and are associated with other diseases, not all of which are associated with head trauma. CTE has been identified in deceased athletes who participated in soccer, ice hockey, boxing, and martial arts; military personnel; and victims of domestic abuse [3]. It is more accurate to describe CTE as a disease associated with exposures to repetitive head trauma rather than a football disease.

Pathologically, CTE involves the abnormal deposition of tau-protein and amyloid plaques in specific regions of the brain. The pattern of this deposition is specific to CTE and distinct from other tauopathies. In addition, the disease itself is distinct from other neurodegenerative diseases like Alzheimer disease or Parkinson disease. A consensus panel published a set of diagnostic criteria for CTE [4]. It is still a disease that is confirmed on autopsy, and prediction of its presence in living individuals is not currently possible.

The current literature supports a theory of repetitive brain trauma, including concussive and subconcussive blows, as the leading risk factor for the development of CTE. Much of the current research is focused on identifying the disease accurately in living individuals.

Unfortunately, we do not know which athletes are at greatest risk and cannot stratify athletes into risk pools for participation. Perhaps most importantly, we do not know the "threshold" of trauma a human brain can tolerate without exhibiting long-term effects. Clearly, the majority of retired professional athletes exposed to repetitive brain trauma live long, full, healthy lives. However, we know that some athletes are suffering from a poorly understood form of dementia that we associate with similar exposures to those who remain asymptomatic.

The available literature suggests that CTE is not a disease that stems from involvement in youth football. When confirmed, it is found in former professional and collegiate American football players, boxers, and martial artists. There are no current studies available for the long-term neurocognitive health of youth football participants. For the purposes of this family discussion, we will make the assumption that we are talking participating in football through high school but not beyond. As such, the most relevant data are those published by Deshpande et al [5]. This cohort study reviewed nearly 2700 male athletes (834 played football and 1858 did not) in the graduating high school class of 1957 and evaluated their cognitive function and emotional status at 65 years of age. The authors found no cognitive or depressive differences in athletes who participated in high school football compared with those who did not participate. Secondary outcomes, like heavy alcohol use, anger and hostility indices, and cognitive scores at age 72 years, were also similar.

A more complete understanding of CTE will require longitudinal studies of individuals with and without exposure to repetitive head trauma, with and without neurocognitive complaints, and with close attribution of other contributors (eg, alcohol, drug use, psychiatric diagnoses) [3]. In addition, there is an inherent selection bias for the athletes who have donated their brains to the study of this disease. We may be finding CTE in artificially greater percentages of studied brains, as athletes without symptoms may be less likely to donate their brains for study.

In this case, the child has no previous medical history of concussion or concussion-modifying factors (eg, psychiatric disorders, learning disability, etc). Other than his age of <18 years [6], I feel that the participation in football for this child is safe, given our current understanding of CTE, and would not advocate against his participation. I would recommend that the family spend some time discussing this decision among themselves and with their son. It is not medically reasonable to disqualify him based on the available literature and the current standard for disqualification. In addition, disqualification is not defensible in this scenario, given the athlete has no clear risk of injury or sudden death and that the sport is considered safe for participation [7].

References

Christine Greiss, DO, Responds

Lately, it is not unusual to see the words football and chronic traumatic encephalopathy (CTE) in the same sentence; both are individually and simultaneously hot topics. The main issue here is whether this child’s participation in football ultimately increases his chances of developing CTE.

CTE is a neurodegenerative tauopathy characterized by the deposition of hyperphosphorylated tau (p-tau) protein...
as neurofibrillary tangles, astrocytic tangles, and neurites in multiple clusters around small blood vessels of the cortex, typically beveled in the sulci. Clinically, CTE manifests as behavioral and mood changes, memory loss, cognitive impairment, and ultimately, dementia. Like many other neurodegenerative diseases, CTE is definitively diagnosed only by postmortem neuropathologic examination of brain tissue. It has been postulated to be associated with recurrent concussive and subconcussive injuries (ie, repetitive head impacts [RHI]).

American football is a collision sport in which head impact is a routine occurrence. My concern is that unlike soccer, baseball, or track, it is the repetitiveness of head impacts on the football field, not necessarily a single forceful impact or concussion, that may increase the chances of developing CTE. In 1 study of 177 football players who were found to have CTE, there was a correlation between years of football exposure and severity of CTE, with high school football players displaying mild CTE on histopathology and players in the National Football League (NFL) displaying severe CTE [1]. Therefore, I would advise this child against participating in football.

Furthermore, the risk of sustaining some sort of head impact (whether concussive or subconcussive) occurs not only during games but also during practice. The front of the head is the most common location of impact for contact drills. Open-field tackling has the greatest average horizontal acceleration and results in significantly greater torsional acceleration, creating the perfect recipe for axonal injury. Multiplayer tackling drills increase the chance of RHI. It has been demonstrated that high school football players intentionally use their helmet to hit opposing players during all forms of tackling [2]. Hence, RHIs simply cannot be avoided. Even in the absence of concussion, neuroimaging demonstrates microstructural changes in certain white matter tracts of some asymptomatic football players after a single season [3]. It is theorized that these are a result of repetitive, subconcussive blows to the head.

This child is 13 years old. Children in this age group have more space between their brain and the skull. This allows for more intracranial brain movement during rapid accelerations and therefore "room to shake" on impact, thus making younger athletes more susceptible to injury during a delicate neurodevelopmental time. Contrary to previous belief, we now know that youth are at greater risk of injury at lower-impact severities compared with adults. Likewise, they are more likely to suffer persistent symptoms [4].

Current research is attempting to bridge the knowledge gap between concussion and CTE. Brains of teenage athletes who had documented concussion were autopsied and found to have astrocytosis, myelinolysis, axonopathy, microvascular injury, perivascular neuroinflammation, and phosphorylated tau protein pathology. These are all hallmarks of CTE [5]. Hence, this is not just a disease of the elderly. Furthermore, decreased axonal conduction velocity in the hippocampus, and defective synaptic neurotransmission in the prefrontal cortex, also were discovered in this population. Some argue that this may explain the manifestation of neurocognitive deficits that develop after RHIs [4,5].

Although this 13-year-old child denies having sustained a concussion, it is difficult to say whether that is accurate. Evidence shows that even professional players in the NFL have a distorted interpretation of a concussion. A study examined former NFL players’ understanding of the concussion definition [6]. These NFL players reported 5 times the number of concussions after being educated on the symptoms that a concussion diagnosis entailed. If a professional NFL player cannot consistently or accurately report concussions, how can we expect this young adolescent to keep track of concussions and subconcussive injuries? Furthermore, male participants are more likely to sustain a concussion from a contact sport, experience loss of consciousness, confusion, and suffer behavioral changes after a concussion and are less likely to report injury compared with female participants [7]. This creates a recipe for disaster by increasing the chances of RHIs, potentially subjecting this child a lifetime of deficits, and predisposing him to the development of CTE.

As a result of frequent head impacts during football practices and games, research suggests that neurocognitive changes may develop in the absence of a clinically diagnosed concussion [8]. There is a chance that he will have problems learning new material because of inattention and poor memory. He may not be able to sustain his above-average grades in school. He may temporarily be out of school because of symptoms and may have to return on a modified schedule. Compared with collegiate athletes, neurocognitive deficits in this younger age group with less brain maturity may take longer to resolve even when concussion-related symptoms have dissipated [9].

This child with a bright future may face behavioral problems as a result of playing football. He is at risk for psychiatric symptom development, sleep disturbance, and irritability, despite a negative history of such [10]. In this delicate adolescent age when there is already a pre-existing struggle with identity and personality development, the impact that a parallel neurobehavioral problem can have on this child could be overwhelming. Some studies demonstrate significant long-term neuropsychiatric and cognitive sequelae based on age of first exposure to American football. Younger age, before 13 years, predicts increased odds for clinical impairment, self-reported neuropsychiatric symptoms, and impairment in executive function [11]. Contrary to previous belief, these ominous symptoms last longer than mere days to weeks, and, if persistent enough, could possibly be the first signs of CTE. For instance, football players who sustain concussive injuries have a 9-year risk of developing clinical depression after retiring from the game [12].

As noted, subconcussive impacts that do not result in clinical signs or symptoms are speculated to lead to alterations in cerebral structure and function later in life. The parents of this child are rightfully concerned. They do not want to render their son as another statistic. They are aware that they cannot avoid RHIs (asymptomatic hits) or...
conusions (symptomatic hits). Moreover, the line between RHIs transitioning into CTE has not been defined. We do not have a “magic number” reassuring this athlete that he will not develop CTE if he avoids hitting his head more than “X” amount of times. Even when good coaching, team culture, and modified technique are implemented, it is nearly impossible to standardize these well-intentioned “changes” in football.

This child is an above-average student with an excellent profile who wishes to become an engineer in the future; why pose a risk to these chances, and succumb him to a lifetime of learning difficulties, behavioral problems, or other deficits? We constantly counsel patients against exposing any other organ in the body to such negligence, why not the brain? We live in an era in which we advise our children to wear seatbelts, limit screen-time, and count calories. Moreover, we have become sharpened on determining the appropriate age for drinking, tobacco purchase, and driving.

In a time in which cognitive capacity is attractive, complexity of the mind is cherished, the value of mental health is appreciated, and the speed of information processing determines success, it would be calamitous to put such a valuable and irreplaceable organ, this child’s brain, at risk by allowing him to participate in football at the age of 13. After all, he only has one.

References


Scott Laker, MD, Rebuts

I disagree that Dr Greiss’ discussion supports the conclusion that participation in youth football for a healthy 13-year-old boy would result in “calamity.” There is no evidence presented that suggests participation in youth football results in CTE. Should this athlete decide to play in junior high school, high school, college, and beyond, the discussion should change to address these different playing environments and the current understanding of the risks for CTE development in each. The current state of understanding allows for all providers to responsibly allow youth athletes to participate in football.

I have no doubt that my colleague wants only the very best for her patients, as do we all. However, I have concerns that these well-intentioned conclusions overreach the evidence. Dr Greiss cites only 1 article that uses CTE as an outcome, and it is a study of 202 deceased football players. She neglects to note that neither of the 2 brains of athletes with only pre-high school football participation showed signs of CTE [1].

This study is too small and too divergent from our scenario to inform our decision. It would be most accurate to say that we have an early and incomplete understanding of CTE, especially in youth athletes.

The remainder of her response is mostly based on small, retrospective, observational studies, with a heavy reliance on self-report and outcomes that have nothing to do with CTE. Throughout her discussion, there are strong, definitive conclusions based on early data. For example, her conclusion that a study of 15 adolescents with a history of recent concussion (average 53 days postinjury), showing no abnormalities compared with controls on symptom scores or ImPACT testing but only slight differences to norms on a test designed for acute concussion, suggests that football creates “a recipe for disaster” and that the child may face a “...lifetime of deficits” and “...predisposes” him to CTE is ludicrous [2]. At most, this study is underpowered and shows mixed results, none of which have anything to do CTE.
The statement suggesting that prolonged symptoms could be "early CTE" is pure speculation and flies in the face of the current understanding of concussion and postconcussion syndrome. If anything, Dr Greiss makes an argument that the acute and subacute consequences of concussion make football an unappealing sport for this young man.

The urge to be paternalistic and err on the side of overprotection is strong in youth athletics but must be tempered with objectivity and respect for autonomy. We must stay consistent in our approach and let the evidence guide our medical decision-making. We must not allow our personal beliefs, no matter how altruistic, to overwhelm the available science.

References

Christine Griess, DO, Rebuts

As professionals, patients come to us for advice. Therefore, our duty is to educate. Beyond the sports participation physical, these parents are doing the right thing by questioning their son’s participation in football. Disqualification of youth from tackle football is currently a major discussion item among members of the American Academy of Pediatrics because of the uncertainty that lies between subconcussive blows and CTE. In October 2015, the Academy concluded that rule enforcement by coaches, removal of tackling altogether, expansion of nontackling leagues, delaying the age at which tackling is introduced, and more placement of athletic trainers on the sidelines would decrease the number of subconcussive impacts on the field [1]. It states, “The American Academy of Pediatrics recognizes, however, that the removal of tackling from football would lead to a fundamental change in the way the game is played. Participants in football must decide whether the potential health risks of sustaining these injuries are outweighed by the recreational benefits associated with proper tackling.” Is that not similar to the statement, “swim at your own risk?” We are in the dark ages of this emerging science and cannot afford to be naïve. It may take years before these changes are implemented in each high school across the country. Until then, this child is not safe and the parents cannot be expected to give informed consent on an unclear matter such as this.

CTE is a structural, not a functional, diagnosis [2]. Parallel to dementia, and metaphorically to coronary artery disease, CTE is a disease that progresses over time [3]. We may not be able to find the direct correlation or specific factor linking repetitive head injuries to CTE. Similarly, how many drinks lead to cirrhosis? How many smoking years lead to lung cancer? How much fried food ingestion leads to coronary artery disease and myocardial infarction, or alcoholism and cirrhosis? Later, we recognized the correlation. Likewise, we have emerging evidence that repetitive subconcussive blows during tackle football are not completely benign. It would behoove us as practitioners to go above the call of duty and warn our patients of the significant risks of permanent brain injury with football participation and recommend that they not participate.

References

Jonathan Finnoff, MD, Guest Commentary

For physicians practicing sports medicine, this scenario is not uncommon. A healthy, smart, and athletic young athlete wants to participate in a contact sport, and their family has concerns about the long-term risks associated with such participation. Both Dr Greiss and Dr Laker make well-formulated arguments supporting their respective positions. It is well established that repetitive concussive blows to the head cause neuropathologic changes. However, the clinical manifestations of this neuropathology are less clear. Thus, there isn’t a definitive “right answer” to the question posed by this scenario.

One thing that is clear is the negative impact of not participating in sports. There is an epidemic of inactivity...
and obesity that is striking not only our nation but the entire world [1]. Estimates suggest that 42 million children globally are overweight or obese, and that most of these children remain overweight or obese throughout their lives [1]. It is well established that inactivity and obesity negatively impact health by predisposing to multiple different pathologies such as diabetes mellitus, hypertension, dyslipidemia, heart disease, musculoskeletal disorders, mental health problems, and certain forms of cancer [1]. Furthermore, inactivity and obesity significantly reduce lifespan [2]. When weighing the potential risks of contact sports participation against the well-established risks of inactivity, one must be very careful about deterring a child’s enthusiasm for sport since it may lead to dire consequences.

Although there may not be a definitive “right answer” to the question posed by this scenario, there certainly is an appropriate approach. This approach involves providing the athlete and their family with all of the available information about the potential positive and negative ramifications of participating in a particular sport and helping them make an informed decision regarding participation. If they choose not to participate in that sport, I believe it is important to help them identify a viable sports alternative. As physiatrists, we are uniquely qualified to provide this counseling since the foundation of our specialty is exercise prescription. Embrace this powerful skillset and let the tenet “Exercise is Medicine” help guide you through the complexities of clinical medicine.

References